magnetic thickness between the two layers of the first and second ferromagnetic layers, and can be reduced.

From the formula (1-4), it is understood that reducing (Ms×t)pin in the pinned layer is effective for reducing Hpin.

However, for bias point designing in ultra-thin free layers, only the reduction in Hpin is meaningless. For this, the reduction in the current magnetic field Hcu is indispensable. Therefore, the nonmagnetic high-conductivity layer is provided on the free layer at the side opposite to the side of the spacer layer, whereby the center of the current distribution in the spin valve film can be near to the free layer and Hcu can be thereby reduced. This is because, in the formulae (1-5) and (1-5-1), when $I_3$ is increased for the top-type spin valve film ($I_1$ is increased for the bottom-type spin valve film) and the current flow ratio C is lowered, then the current magnetic field Hcu can be reduced. Another significant function of the nonmagnetic high-conductivity layer is to maintain high MR ratio in the ultra-thin free layer, to which the invention is directed, owing to the spin filter effect. Specifically, by providing the nonmagnetic high-conductivity layer, the difference in the mean free path of up-spin can be kept large between the parallel condition and the antiparallel condition for the magnetization directions of the free layer and the pinned layer adjacent to the spacer.

For stably realizing the condition of Hpin - Hin = Hcu,

the reduction in Hin is also important. For realizing the high MR ratio owing to the high-conductivity layer as provided adjacent to the ultra-thin free layer (spin filter effect), it is important to thin the spacer. However, in general, Hin will increase with the reduction in the spacer thickness and with the reduction in the free layer thickness. Overcoming this problem, it is important to use the device of the invention at Hin falling within a range of from 0 to 20 Oe or so.

Fig. 2 is a schematic view of the transfer curve given by the spin valve film of the invention. Even in the small transfer curve for which the ultra-thin free layer is used to give small Hs, all of Hpin, Hcu and Hin are reduced, and it is possible to design the condition of Hpin - Hin = Hcu. Therefore, it is possible to settle the bias point in a good site of around 50 %(good bias point around 40 % in the value calculated by our method). In addition, since the film incorporates the high-conductivity layer exhibiting the spin filter effect, it still maintain high MR ratio even in the ultra-thin free layer. The value in the vertical axis in Fig. 2 is satisfactorily high.

Next, the determinant factors for the bias point, namely the parameters of Hpin, Hin and Hcu are described in detail.

First, low Hcu is referred to. As previously described hereinabove, the high-conductivity layer is provided on the free layer at the side opposite to the side of the spacer,

whereby the value C in the formula (1-5) is reduced and the current magnetic field Hcu is reduced. One concrete example of the film constitution is mentioned below.

5 nanometer Ta/x nm Cu/2 nm CoFe/2 nm Cu/2.5 nm CoFe/0.9 nm Ru/2 nm CoFe/7 nm IrMn/5 nanometer Ta

Fig. 3 is a graph of the Cu thickness of the high-conductivity Cu layer adjacent to the free layer on the side opposite to the side at which the spacer is contacted with the free layer, versus the current magnetic field Hcu applied to the free layer. The sense current is 4 mA. As illustrated, the value C of the formula (1-5) becomes small with the increase in the Cu film thickness, whereby the current magnetic field Hcu is reduced. When the current flow ratio in the upper and lower sides of the free layer is the same, the current magnetic field applied to the free layer is always zero irrespective of the intensity of the sense current applied thereto.

One key point of the invention is to reduce the current magnetic field. However, it is undesirable to make the current magnetic field Hcu zero. The invention satisfies the condition of Hpin - Hin = Hcu for bias point control. Therefore, designing the current magnetic field to reach zero, as in the Comparative Case 3 mentioned above, will make the intended bias point control impossible.

From the viewpoint of the current magnetic field, the suitable range of the nonmagnetic high-conductivity Cu layer